

1. A system for hierarchically storing packetized data and transferring the packetized data, the apparatus comprising:

- an input configured to receive packets of data;
- a memory coupled to the input and configured to store packets of data;
- an output coupled to the memory and configured to transfer packets of data from the memory; and

a controller coupled to the memory and configured to control the memory to store packets of data in queues associated with a hierarchy in which a first level of the hierarchy includes a group of queue group components, wherein at least one of the queue group components in the group at the first level includes a group of queue group components associated with a second level of the hierarchy that is different from the first level of the hierarchy.

2. The system of claim 1 wherein each queue group component is associated with at least one of a logically-lower queue and a logically-lower queue group, and wherein the controller is configured to control the memory to store packets of data in  $N$  levels of the hierarchy, wherein  $N$  is greater than two and wherein at least one queue group component in each level other than the two logically-lowest levels includes at least two queue group components associated with a logically-lower level.

3. The system of claim 2 wherein the at least two queue group components associated with a logically-lower level are associated with a level immediately logically lower in the hierarchy.

4. The system of claim 1 wherein the controller is configured to control the memory to store multiple groups of queue group components in association with the first level of the hierarchy.

5. The system of claim 1 wherein each queue group component is associated with at least one of a logically-lower queue and a logically-lower queue group, and wherein the controller is configured to determine a discard priority, of at least one of the queue group components in the group of queue group components at the first level, for packet discard selection.

6. The system of claim 5 wherein the controller is configured to determine the discard priority based on at least one of queue size, type of source, size of source, and service requirements associated with a queue.

7. The system of claim 5 wherein the controller is configured to determine a discard value.

8. The system of claim 7 wherein the discard value varies directly with queue size.

9. The system of claim 5 wherein the controller is configured to determine a discard priority, of at least one of the queue group components at the second level, for packet discard selection.

10. The system of claim 9 wherein the controller is configured to determine the discard priority for packet discard selection for the at least one queue group component at the first level and the at least one queue group component at the second level differently.

11. The system of claim 5 wherein the controller is configured to discard at least one packet of data of a queue associated with a queue group component having a highest discard priority of the queue group components in the group at the first level.

12. The system of claim 11 wherein the group of queue group components at the first level is a first group, and wherein the controller is configured such that if the queue group component having the highest discard priority of the queue group components in the first group includes a second group of queue group components at the second level, the controller determines a discard priority for each queue group component of the second group of queue group components and discards at least one packet of data of a queue associated with a queue group component in the second group having the highest discard priority from among the second group.

13. The system of claim 11 wherein the at least one packet discarded by the controller is disposed at one of a head of, a tail of, and a random location in, the queue associated with the queue group component having the highest discard priority of the queue group components in the first group.

14. The system of claim 11 wherein the controller is configured to discard multiple packets of data from the queue associated with the queue group component having the highest discard priority regardless of whether the discard priority changes before all of the multiple packets of data are discarded.

15. The system of claim 7 wherein the controller is configured to determine the discard value for at least one queue group component in the group at the first level in a different manner than for at least one other queue group component in the group at the first level.

16. The system of claim 7 wherein the controller is configured to determine the discard value for the queue group component at the first level of the hierarchy that includes the group of queue group components at the second level of the hierarchy, the primary component, based on at least one of an effective size of the and an effective size of a queue, at a level logically lower in the hierarchy than the second level, that is associated with at least one of the components at the second level that is associated with the primary component.

17. The system of claim 5 wherein the controller is configured to discard at least one packet of data of a queue associated with a queue group component having approximately a highest discard priority of the queue group components in the group at the first level.

18. The system of claim 5 wherein the controller is configured to discard at least one packet of data of a queue associated with a queue group component having a discard priority that

is within a highest-priority range of discard values that is associated with at least one of the queue group components in the group of queue group components at the first level.

19. The system of claim 5 wherein the controller is configured to discard at least one packet of data of a queue associated with a queue group component in response to the memory at least attempting to store an amount of data that would exceed a data amount limit for the memory.

20. The system of claim 5 wherein the controller is configured to discard at least one packet of data of a queue associated with a queue group component in response to the memory at least attempting to store an amount of data that would exceed a data amount limit for a group of queues.

21. The system of claim 20 wherein the at least one packet of data is discarded from a queue other than a queue associated with the group whose data amount limit the memory at least attempting to exceed.

22. The system of claim 20 wherein the at least one packet of data is discarded regardless of whether the memory is at least attempting to store an amount of data that would exceed a data amount limit for the memory.

23. The system of claim 5 wherein the controller is configured to discard at least one packet of data of a queue associated with a queue group component according to at least one of:

in response to the memory at least attempting to store an amount of data that would exceed a data amount limit associated with the system, and random early discard.

24. The system of claim 23 wherein the data amount limit is a queue size limit.

25. A system for hierarchically storing packetized data and transferring the packetized data, the apparatus comprising:

an input configured to receive packets of data;

an output coupled to the memory and configured to transfer packets of data from the memory; and

control means coupled to the input and to the output for storing packets of data received by the input in queues associated with a hierarchy where each level of the hierarchy includes at least one group of queue group components, and where at least one of the queue group components in each level other than a lowest level of the hierarchy includes a group of queue group components associated with a logically-lower level of the hierarchy, each queue group component being associated with at least one of a logically-lower queue and a logically-lower queue group, the control means also for transferring stored packets of data to the output.

26. The system of claim 25 wherein the logically-lower level is immediately logically lower in the hierarchy.

27. The system of claim 25 wherein the control means is also for determining effective lengths of the queue group components.

28. The system of claim 27 wherein the control means is configured to determine the effective lengths based on at least one of queue size, type of source, size of source, and service requirements associated with a queue.

29. The system of claim 28 wherein values of the effective length vary directly with queue size.

30. The system of claim 29 wherein the control means is also for discarding at least one packet of data of a selected queue associated with a queue group component that has a longest effective length among a hierarchical group under consideration for discard.

31. The system of claim 30 wherein the hierarchical group under consideration is associated with a queue group component at a higher level in the hierarchy that has the longest effective length of its associated group.

32. The system of claim 31 wherein the control means is for discarding multiple packets of data from the selected queue regardless of whether the queue group component associated with the selected queue ceases to have the longest effective length in its group before all of the multiple packets of data are discarded.

33. The system of claim 27 wherein the control means is configured to determine the effective lengths for at least two different hierarchical components differently.

34. The system of claim 27 wherein the control means is configured to discard at least one packet of data of a queue associated with a queue group component having an effective length that is within a highest-length range of effective lengths associated with a hierarchical group under consideration for discard.

35. A system for hierarchically storing packetized data and transferring the packetized data, the system comprising:

an input configured to receive packets of data;  
a memory coupled to the input and configured to store packets of data;  
an output coupled to the memory and configured to transfer packets of data from the memory; and  
a controller coupled to the memory and configured to control the memory to store packets of data in queues associated with a hierarchy in which a first level of the hierarchy includes a group of queue group components, wherein at least one of the queue group components in the group at the first level includes a group of queue group components associated with a second level of the hierarchy that is different from the first level of the hierarchy each queue group component being associated with at least one of a logically-lower queue and a logically-lower queue group;

wherein the controller is configured to control the memory to store packets of data in N levels of the hierarchy, wherein N is greater than two and wherein at least one queue group component in each level other than the two logically-lowest levels includes at least one queue group and one other queue group component associated with a logically-lower level; and

wherein the controller is configured to determine a discard priority, of each queue group component in the group of queue group components at the first level, for packet discard selection, the discard priority based on a discard value that varies directly with queue size of queues associated with the queue group components.

36. The system of claim 35 wherein the controller is configured to determine the discard priority also based on at least one of type of source, size of source, and service requirements associated with a queue.

37. The system of claim 35 wherein the controller is configured to determine the discard priorities for packet discard selection for different hierarchy group components differently.

38. The system of claim 35 wherein the controller is configured to discard at least one packet of data of a selected queue associated with a queue group component having a highest discard priority of the queue group components in the group at the first level.

39. The system of claim 38 wherein the controller is configured to discard multiple packets of data from the selected queue regardless of whether the discard priority of the queue group component associated with the selected queue changes to less than the highest discard priority of its group before all of the multiple packets of data are discarded.

40. The system of claim 35 wherein the controller is configured to discard at least one packet of data of a selected queue associated with a queue group component having approximately a highest discard priority of the queue group components in the group at the first level.

41. The system of claim 40 wherein the queue group component having approximately the highest discard priority has a discard priority that is within a highest-priority range of discard values that is associated with at least one of the queue group components in the group of queue group components at the first level.

42. A method for hierarchically storing packetized data and transferring the packetized data, the method comprising:

- receiving packets of data at an input; and
- storing the received packets of data in queues according to a hierarchy where each level of the hierarchy includes at least one group of queue group components, and where at least one of the queue group components in each level other than a lowest level of the hierarchy includes a group of queue group components associated with a logically-lower level of the hierarchy each queue group component being associated with at least one of a logically-lower queue and a logically-lower queue group.,

43. The method of claim 42 wherein the lower level is immediately logically lower in the hierarchy.

44. The method of claim 42 further comprising determining effective lengths of the queue group components.

45. The method of claim 44 wherein determining the effective lengths is based on at least one of queue size, type of source, size of source, and service requirements associated with a queue.

46. The method of claim 45 wherein values of the effective length vary directly with queue size.

47. The method of claim 46 further comprising discarding at least one packet of data of a selected queue associated with a queue group component that has a longest effective length among a hierarchy group under consideration for discard.

48. The method of claim 47 wherein the hierarchy group of queues under consideration is associated with a queue group component at a higher level in the hierarchy that has the longest effective length of its associated group.

49. The method of claim 48 wherein the discarding of at least one packet includes discarding multiple packets of data from the selected queue regardless of whether the queue group component associated with the selected queue ceases to have the longest effective length in its group before all of the multiple packets of data are discarded.

50. The method of claim 44 wherein determining the effective lengths for at least two different hierarchy components is determined differently.

51. The method of claim 44 further comprising discarding at least one packet of data of a queue associated with a queue group component having an effective length that is within a highest-length range of effective lengths associated with a hierarchy group under consideration for discard.